AERONAUTICAL AND ASTRONAUTICAL ENGINEER

FUEL-OPTIMAL LOW-EARTH-ORBIT MAINTENANCE

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First-order solutions indicate that a forced Keplerian trajectory (FKT) obtained by thrust-drag cancellation is as fuel-efficient as a Hohmann transfer. Further analysis has shown that the FKT is not Mayer-optimal. Therefore, there must exist another trajectory that matches or exceeds the efficiency of the Hohmann transfer. The application of this result to the fuel-optimal orbit maintenance problem implies that periodic reboosts must be more efficient than an FKT profile. This research begins with the formulation of an optimal periodic control (OPC) problem to determine the minimum fuel-reboost strategy. The problem is numerically solved by a spectral collocation method. The optimization code is further modified to increase accuracy and reduce sensitivity to initial guesses. The results of this effort identified a trajectory for a sample satellite that was 3.5% more efficient than an ideal impulsive Hohmann transfer over the same period of time. From the optimal code, a maximum thruster size is also identifiable for a set of initial conditions. The optimal trajectory can save as much as 10% of the propellant budget when compared to finite-bum Hohmann transfers.

DoD KEY TECHNOLOGY AREAS: Aerospace Propulsion and Power, Space Vehicles, Modeling and Simulation

KEYWORDS: Orbital Maintenance, Orbital Mechanics, Hohmann Transfer, Orbit Reboost, Orbit Transfer, Forced Keplerian Trajectory, Optimization, Periodic Control

TURBOCHARGERS TO SMALL TURBOJET ENGINES FOR UNINHABITED AERIAL VEHICLES

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Three test programs were conducted to provide the preliminary groundwork for the design of a small turbojet engine from turbocharger rotor components for possible Uninhabited Aerial Vehicle applications. The first program involved the performance mapping of the Garrett T2 turbocharger centrifugal compressor. The second program involved the bench testing of a small turbojet engine, the Sophia J450, at 115000 RPM, and comparing the results to another small turbojet, the JPX-240, from previously documented research. The compressor radii of the two engines were identical but greater than that of the Garrett compressor. The two engines, despite their physical similarities, had different fuel requirements. The J450 used heavy fuel (fuel pump required) while the IPX used liquid propane (pressurized fuel tank required). The third program involved the performance prediction of the J450 using GASTURB cycle analysis software. The compressor map generated

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from the Garrett T2 test was imported into GASTURB and used to predict the J450 performance at 94000, 105000, 115000, and 123000 RPM. The performance predictions agreed reasonably well with actual J450 performance.

DoD KEY TECHNOLOGY AREAS: Aerospace Propulsion and Power, Air Vehicles

KEYWORDS: Centrifugal Compressor, Turbomachinery, Uninhabited Aerial Vehicles (UAV), GASTURB, SMOOTHC, Turbojet, Turbocharger

ELECTRICAL ENGINEER

DEVELOPMENT OF ANALYSIS TOOLS AND INCORPORATION OF COMMERCIAL DIGITAL SIGNAL PROCESSORS IN A SIGNAL ANALYSIS GRAPHICAL USER INTERFACE

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This work is part of an ongoing effort to integrate the separate BEARTRAP post mission analysis tools into an application operating in a Microsoft Windows environment. This new integrated system will contain software modules designed to replace the array of diverse processing systems currently being used for BEARTRAP post mission analysis. This thesis develops the module responsible for Fast Time Analysis. This module allows an analyst to generate, display, and analyze broadband and narrowband sonograms collected from a BEARTRAP mission. The overall objective of the module is to quickly identify acoustic events of interest. This document describes the development of the generation and display of broadband and narrowband grams using Microsoft Visual C++ as the implementation language, the development of the tools necessary for gram analysis, the development of a supplemental digital signal processing board for increased computational power, and the testing of the various parts of the Fast Time Analysis module in a standalone Microsoft Windows application.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Sensors

KEYWORDS: DSP, Narrowband, Broadband, BEARTRAP, Graphical User Interface

MECHANICAL ENGINEER

AUV FAULT DETECTION USING MODEL BASED OBSERVER RESIDUALS
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In order for the Navy's next generation Unmanned Undersea Vehicles to be more robust to software/hardware faults, on-line failure detection and resolution is needed. Typically, fault detection methods include limits and trends analysis, model free, and model based techniques. Here, model based observers are proposed for the detection of fault induced dynamic signals in the diving, steering, and roll control systems. Such automatic fault detection systems were designed and implemented in a *Simulink* model of the "2 1UUV." In the course of conducting simulations with the model, numerous vehicle behaviors were studied and detection response was verified. In addition, the model based observer residuals may be designed to distinguish actuator faults from wave disturbances and fin faults from maneuvering responses.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles-Ships and Watercraft, Modeling and Simulation

KEYWORDS: Model Based Observers, 21UUV, AUVs, Fault Detection

TRANSIENT RESPONSE ANALYSIS OF THE 72 INCH TAC-4 RUGGEDIZED SHIPBOARD RACK SUBJECTED TO AN UNDERWATER EXPLOSION EVENT
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The finite element modeling and subsequent transient analysis of the 72 Inch TAC-4 Rugged Rack computer system (configurations 000 1AA and OOO3AA only), currently employed in U.S. Navy shipboard applications, has been performed to determine the system's response to simulated shock inputs. This rack is designed to allow incorporation of commercial-off-the-shelf (COTS) computer systems for naval tactical computing requirements while still meeting MJL-STD-901D, the applicable shock specification. By showing the viability of this computer simulation of the shock response of the current TAC-4 rack system, an argument for a lessening of the actual physical testing requirements for acceptance of future TAC systems can be made.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Transient Analysis, Finite Element Method, TAC-4, COTS, Shock Analysis, UNDEX

HUMAN MALE AND FEMALE BIODYNAMIC RESPONSE TO UNDERWATER EXPLOSION EVENTS

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Ship survivability is a complex issue. For a ship to remain a viable warfighting asset following damage resulting from enemy munitions such as mines or torpedoes, the ship's crew must remain sufficiently uninjured to be capable of employing the ship's weapons systems. Sophisticated computer simulations of human response, such as those made possible by the Articulated Total Body (ATB) Model, may be used to estimate injury potentials, and thus crew survivability, during underwater explosion events. With this goal in mind, accelerometer data and video footage recorded during live fire testing were used to generate and validate ATB models for both a seated and a standing Hybrid III Anthropomorphic Test Device (ATD). Subsequently, these models were used to estimate the biodynamic response and injury potentials for both male and female human subjects in a vessel subjected to underwater explosion events. This established a method for evaluating crew survivability for a given underwater explosion induced deck excitation.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Biodynamic Response, Underwater Explosion, Articulated Total Body Program